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USING FIRE STREAMS WITH A SELF-PROPELLED OIL SPILL SKIMMER

Archie C. Roberts

Edison Water Quality Research Laboratory

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Using Fire Streams with A Self-Propelled Oil Spill Skimmer

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by

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This report results from field tests and operations conducted by the Marine Division of the New York City Fire Department in the fall of 1972. The objective of the operations was to develop tactics for operation of a fire boat in conjunction with a self-propelled oil skimming boat for oil spill cleanup with minimum use of booms. Streams from the fireboats were used to develop currents for propelling oil toward the skimmer, to maneuver oil in conjunction with natural currents, and to concentrate oil for subsequent pickup by the skimmer.

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SECTION I

CONCLUSIONS

Both from the theoretical study and the limited experience gained from this short experimental program, there are obvious advantages to joint operations between fireboats and self-propelled skimmers such as the SHOC.

1. The fireboat's monitors can provide water streams which, when used both with and without natural currents, can successfully herd oil into windrows for subsequent pickup by the skimmer.

2. The fire streams can reduce or minimize the need for booms in some open water oil spill cleanup operations.

3. These streams have enough energy to create artificial currents which will carry oil under the SHOC for collection.

4. The fireboat can tow the skimmer so that it arrives at the spill area sooner than if it had to proceed under its own power.

5. The fireboat can serve as a supply base for the SHOC which has only limited deck and storage space.

6. Other harbor craft such as tugs which have a large caliber fire stream capability could be used effectively to assist skimming operations.

SECTION II

RECOMMENDATIONS

Keep the SHOC in the New York Area and continue to stage joint training operations between the SHOC and the fireboats.

Train local people in the specifics of the SHOC operation, both from the point of view of equipment use and maintenance, and the development of oil spill control tactics.

Develop the oil transfer and shore disposal logistics needed to make the use of SHOC at actual spills a viable operation.

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SECTION III

INTRODUCTION

The continuing investigation into equipment and tactics for controlling oil spills has resulted in this study of benefits to be derived from a joint operation between fireboats and the Submerged Hydrodynamic Oil Concentrator (SHOC) - a self-propelled, fixed incline plane oil skimmer developed by J&F Scientific Corporation under contract to the U.S. Environmental Protection Agency. This investigation was essentially a continuation of the work previously conducted by the Marine Division of the New York City Fire Department in determining what contributions the nation's fire departments could make to the control of oil spills. The emphasis of the program was placed on the quick response capability of fire departments and their ability to provide early containment of an oil spill while the major containment and pickup facilities were being mobilized. This previous work indicated that the SHOC skimmer would be helpful in augmenting this first-strike capability and the program was expanded in order to make a field evaluation of the concept.

The Skimmer

A report entitled "The Development and Demonstration of an Underwater Oil Harvesting Technique" by Ralph A. Bianchi and George Henry is available as one of the U.S. Environmental Protection Agency's Water Pollution Control Research Series. The details concerning the design, construction, and testing of the SHOC can be found in this publication and will not be duplicated here. However, in order that this report be relatively self-sufficient, a brief description of this skimmer is incorporated here. The boat was designed to take advantage of the principle that water impinging on an inverted inclined plane will tend to flow down and under the plane rather than being diverted to either side. Such an inclined plane was incorporated as the bow of the skimmer boat and, when the boat is proceeding at slow speed (1 to 2 knots) into an oil slick, the oil flows down and under the boat. Just in back of the inclined plane is a free flooding oil collection compartment. The bottom of this compartment is flush with the after end of the inclined plane and is fitted with an array of 3" x 3" baffles 9 inches high. Oil, after coming down the inclined plane, will now tend to rise due to the difference in specific gravity and enter the collection chamber through the baffle section. The baffles increase the efficiency of separation by providing a larger area of vertical surface and breaking up the normal flow pattern in the collecting chamber so that oil once separated will not subsequently be entrained and flushed out. During the skimming operation, oil will gradually displace water in the collection compartment and when sufficient oil has been collected, it can be pumped to an on board storage tank for subsequent transfer to shore.

The prototype SHOC used for the test program was a self-propelled vessel

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22 feet long with a 7 foot 9 inch beam and a 31 inch draft (Figure 1). It has 21 inches of freeboard and two extension brackets aft for mounting a pair of 13 HP outboard motors. The collection chamber takes up the area below the cockpit and is approximately 90 inches long. Forward of the cockpit is a 275 gallon storage tank. The remaining hull spaces are taken up by flotation compartments and ballast tanks. The ballast tanks are positioned at the bow and stern in order to facilitate adjusting the boat's fore and aft trim. On the foredeck is mounted a 4 inch helical pump driven by a 9 HP gasoline motor. The pump is hooked up so that it can be used for pumping skimmed oil into the storage tank or for pumping stored oil ashore. A small auxilliary pump run from the same motor is used for filling or emptying the ballast tanks.

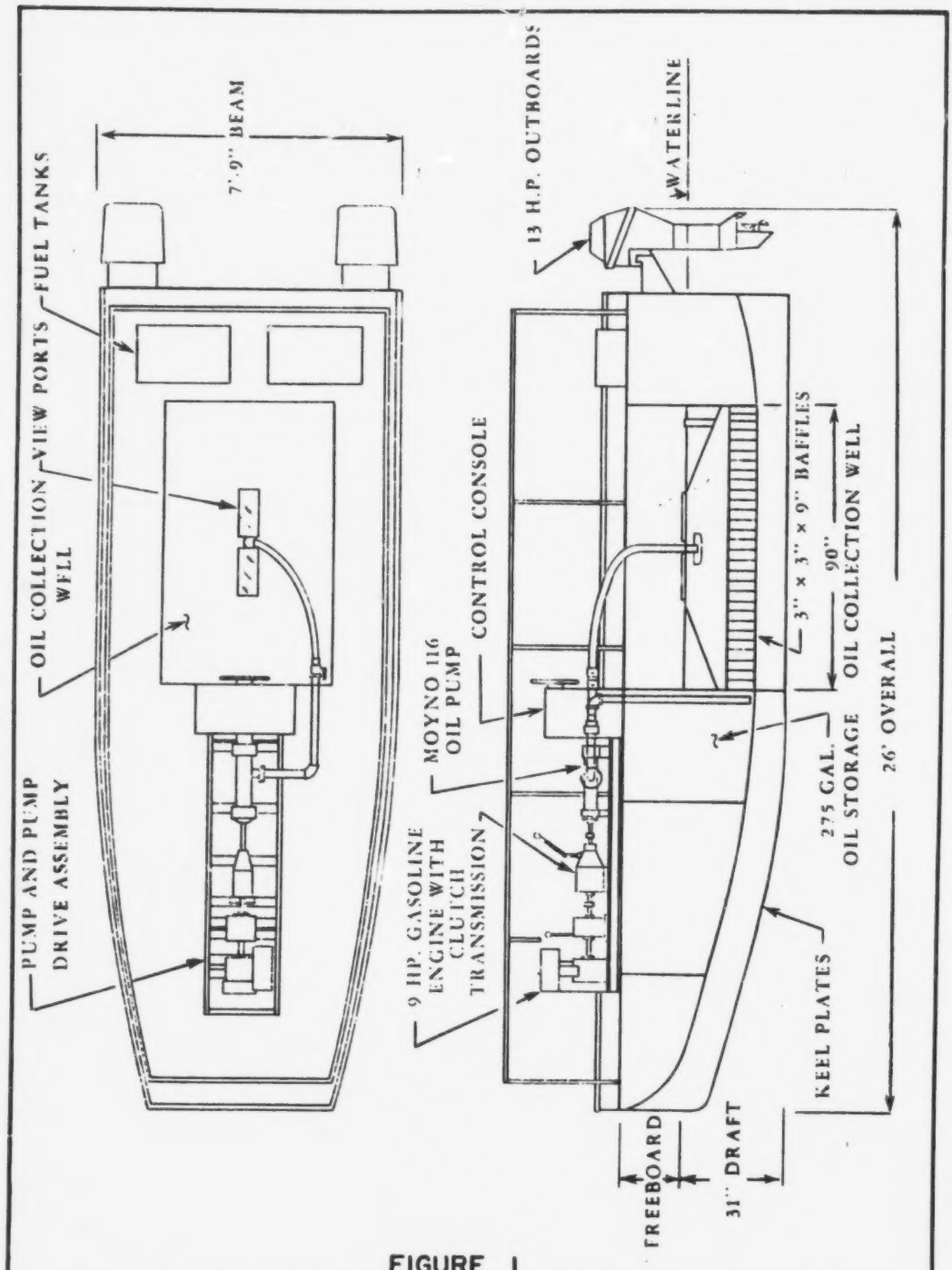

FIGURE 1

OUTLINE DRAWING OF THE "SHOC" DEMONSTRATION UNIT

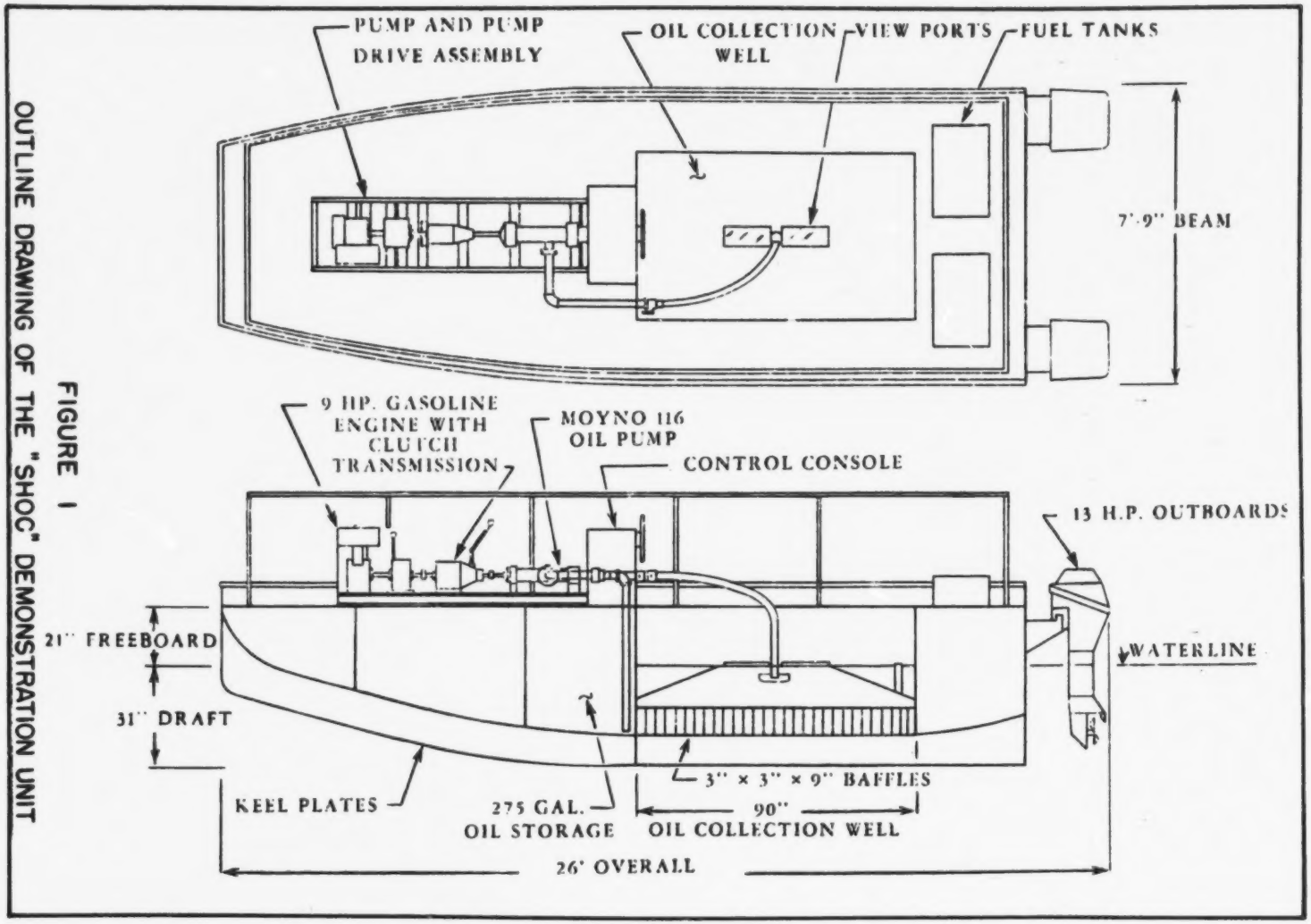

FIGURE 1

OUTLINE DRAWING OF THE "SHOC" DEMONSTRATION UNIT

SECTION IV

PROGRAM

Previous investigations into oil spill control by fire departments has fairly well defined those areas in which they can effectively function. Firemen are trained to cope with emergency situations, and there is an existing command structure with leaders experienced in directing this type of operation. If a fire department is provided with sufficient oil spill control equipment, specifically boom, it can take effective action by deploying the boom in those critical early stages of an oil spill before the oil spreads excessively.

Prime emphasis of the previous work was placed on the development of tactics for using fire streams to contain spreading oil and to herd it into position for future pick up. Subsequently, oil spill control boom was purchased and the fire department investigated methods for its rapid deployment and positioning. Except to the extent needed to facilitate the investigations on streams and boom, the physical removal of the oil from the water was a secondary consideration. Oil skimming can best be performed by other people who have the pick up equipment, the facilities to dispose of the oil in a legally approved manner, and the capability of remaining on-site until cleanup is complete. Once the fire department has taken the initial crucial steps to limit spreading, other agencies should take over and allow fire personnel to attend to their prime function of fire fighting. Six reports on these previous investigations have been published in the EPA Water Pollution Control Research Series (Publications EPA-R2-72-112 through 117). A film entitled "A Fire Department's Response to Oil Spills" was also produced and is available for showing from the EPA.

A knowledge of the techniques for retrieving oil is necessary, however, for meaningful training in control of spreading, and a number of small oil pick up devices were looked at during the life of the program. They were all passive devices requiring umbilicals back to shore (or a fire-boat) for power, oil transfer, and positioning. The SHOC skimmer offered an opportunity for developing techniques for using fire streams to enhance the pick up capabilities of an essentially self-sufficient skimmer which usually operates on its own.

The final phase of the program entailed transporting the SHOC from Boston to New York City, refurbishing it as necessary, and training personnel in its operation. Once these preliminaries were completed, the unit was to be operated at spills of convenience where fire streams could be used to herd oil for subsequent pick up by the skimmer. Fire streams were also to be used to create artificial currents, enabling the pick up of oil with the SHOC standing still. This would provide pick up capability in confined waters where operation underway was precluded. The emphasis was to be placed on the use of fire streams, rather than booms, for control of oil.

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SECTION V

PREPARATIONS AND TRAINING

The SHOC had not been in use for an extended period of time prior to its use in this program and was stored on its cradle out of the water. The unit was specifically designed to be road transportable (less than 8 foot beam) so that it was moved from Boston to New York City on a flat bed trailer and delivered to a Marine Division pier in Brooklyn. The unit required only cleaning and minor repairs to make it serviceable and ready for launching. It was originally planned to lift the boat from the water each day after use; but the maximum capacity of the fireboat's davit is inadequate for lifting the weight (3 tons), and the boat was left in the water for the duration of the project. Some long nylon lines were provided to tie it up, and the boat rode comfortably in the relatively sheltered slip.

Once the boat was in the water, a training program was initiated to familiarize Fire Department personnel with its operation. Although the firemen of the Marine Division have all had previous training in small boat handling, it was necessary that they become familiar with the peculiar handling characteristics of the SHOC because of the probable requirement that it be used in close proximity to oil boom and docks. The boat was found to be quite maneuverable when operating with both outboards working. The two outboards are spaced about 5 feet apart and this provides it with a tight turning radius which is a distinct advantage for this type vessel. Because of the wide spacing, the boat is much harder to control when only one engine is operating, and it is important that both outboards be kept in good working order.

The SHOC collects oil most efficiently when moving from 1 to 2 knots. The two outboards were selected so that the boat could be run at these slow speeds for long periods of time without fouling. The boat was, therefore, underpowered for normal running and some tests were made to see if the SHOC could be moved more rapidly by towing it with a fireboat. One of the Marine Division's 105 foot vessels was used for the test. Of the two towing methods, astern or off-the-hip, the latter was chosen as being the most practical. By towing the SHOC tied alongside, the fireboat's maneuverability was not changed appreciably. Since this particular fireboat had a controllable pitch propeller and did not stop the shaft rotation even when the vessel stopped, it was deemed better to avoid towing the SHOC astern where the tow rope could have even the slightest chance of fouling the propeller.

The test indicated that some advantage could be gained by towing the SHOC rather than letting it proceed to a spill under its own power. With the present engines, cruising speed is about 5 knots. The boat could be towed at 6-1/2 to 7 knots. At speeds in excess of this the bow tended to lift, turbulence in the baffled center section increased, and the boat sat back on its stern and started to fishtail This effect

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was quite pronounced when the SHOC was not fully ballasted down to optimum draft. While towing at 6-1/2 knots the maneuverability of the fireboat was not appreciably affected, with only a few degrees of opposing rudder required to compensate for the SHOC's drag. The towing was done with a 1/2 inch nylon line. In order to expedite early arrival at the scene of a spill, the SHOC should, when circumstances permit, be towed rather than allowed to proceed under its own power. Not only does the skimmer arrive there more quickly, but much of the preparation and rigging for the pick up operation can be accomplished while the boat is underway to the spill area.

Some tests were run to simulate the use of fire streams to herd oil toward the SHOC when it was moored or anchored. The fireboat's bow monitor was used to develop surface currents, and current meter readings were taken around the SHOC to determine the flow characteristics. The skimmer was moored in the center of a slip with two bow lines tied off on the adjacent piers (Figure 2a). The fireboat was positioned to drive water into the slip and the SHOC was held bow into the artificial current by adjusting the length of the bow lines. Current readings were taken fore and aft of the SHOC as well as off to the side. The current was measured by means of a meter using a balanced Savonius rotor transducer with a 1/20 knot threshold. The tests were conducted at slack tide so that there was essentially no ambient current to affect the readings. The fire monitor was adjusted so that it was horizontal and the stream struck the water 50 ft ahead of the SHOC. The monitor was equipped with a 3 inch nozzle.

With the pumping pressure set at 75 psi and an equivalent nozzle pressure of 56 psi, the calculated flow was:

$$Q = 29.7\ d^2\ /P$$

where Q = flow in gal/min
d = diameter in inches
P = pressure in psi

$$Q = 29.7 \times 3^2 \times /56$$
$$Q = 2000 \text{ gpm}$$

This flow created a current of 0.6 knots at the bow with the meter set so that the rotor was centered at 1 ft depth. The current aft at this depth was essentially zero but the current measured 0.4 knots when the meter was lowered to 2 ft below the surface.

As the pump pressure was increased to 100 psi (nozzle pressure of 75 psi) the flow increased to 2300 gpm with increased impact velocity. The same geometry now produced currents of 1.2 knots forward, again zero knots aft at 1 ft, and 0.6 knots aft at the 2 ft depth. The currents port and starboard were the same as the bow readings, indicating that the inclined bow of the SHOC offered no appreciable impedance to flow at relative speeds in the above range.

It is apparent that the fire streams can be used to develop current

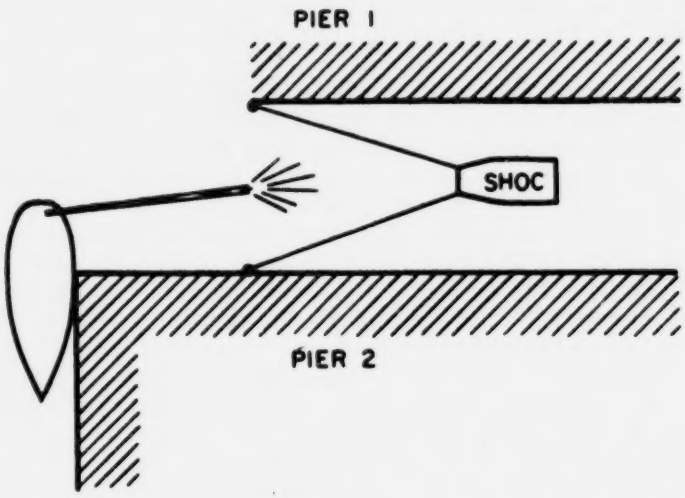

FIGURE 2o
USE OF FIRESTREAMS TO DEVELOP MID STREAM CURRENT
FOR OIL PICKUP BY SHORE LINE

velocities relative to the SHOC equivalent to the speeds recommended as optimum for oil pick up. This plan used to test the flow characteristics is obviously a very inefficient one for picking up oil. Only a small portion of the surface current set up by the fire streams is intercepted by the 5 ft active width of the SHOC and the majority of the flow (oil in an actual spill) passes by on either side.

By slacking one bow line and hauling in on the other, a more favorable situation for intercepting the oil was produced (Figure 2b). The SHOC moved over against the bulkhead on one pier; and, by retraining the monitor, the fire stream was used to create a surface current across the slip and down the bulkhead. It could, therefore, concentrate oil at the mouth of the SHOC, resulting in a more efficient pick up operation.

An extension of this tactic would be the use of oil spill control boom to concentrate oil for pick up by the SHOC. The SHOC is provided with bow fittings originally used for attaching short rigid sweeps. These sweeps were used for preventing loss of the oil spilled in front of the vessel while evaluating pick up efficiency during the testing phase. These fittings can be used for attaching relatively long lengths of oil boom in order to increase pick up efficiency in cases where the SHOC is moored and the oil is either driven toward it by fire streams or the natural current is sufficient to drive the oil down the inclined plane. In cases where the SHOC is underway, picking up oil in open areas, the wings of the oil boom can be held in position relative to SHOC by small boats. This operation requires a great deal of finesse since the SHOC requires a speed through the water of 0.5 knots to attain a reasonable pick up efficiency while at 0.7 knots oil begins to pass under the booms with total containment failure occurring at 2 knots. The oil boom must be, therefore, kept taut and in a relatively sharp V configuration, so that no bellies form and the current speed normal to the boom does not exceed the critical value.

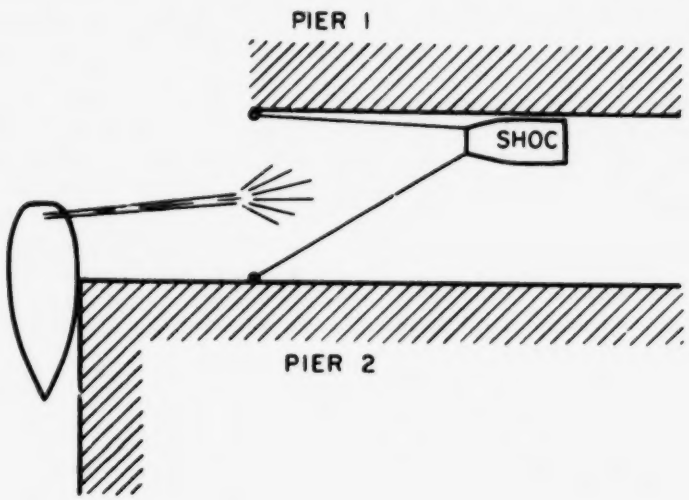

FIGURE 2 b
USE OF FIRESTREAMS TO DEVELOP SHORE LINE CURRENT
FOR OIL PICKUP BY SHOC

SECTION VI

OPERATION AT OIL SPILL

On 28 November, 1972 there was a spill of Number 6 fuel oil into the Arthur Kill at Perth Amboy, New Jersey. The Kill is the body of water which separates Staten Island from New Jersey, and its banks are the location of the terminals and plants which provide a majority of the petroleum products used in the metropolitan New York area. This spill furnished an opportunity to test out some of the tactics developed for joint operation of the SHOC and a fireboat.

When the report of the spill was received, the fireboat Alfred E. Smith proceeded to the SHOC's berth in Brooklyn and took it under tow for the trip down the Kills to Perth Amboy. When the boats arrived on site, it was found that the oil had been spilled in the area of a tanker discharge pier. This pier ran parallel to the shore about 150 ft out from the beach. The coast Guard and an oil spill cleanup contractor were on the scene, and spill boom had been deployed to contain the oil lying between the pier and the shore. Weir-type skimmers and vacuum hoses were being used to pick up the oil. Use of the first type was subsequently suspended because of the oil's viscosity in the near-freezing temperature that prevailed.

Considerable amounts of oil had escaped the booms and was spread out across the Kill. The SHOC was untied from the Smith and runs were made aimed at picking up some of this oil. These initial runs familiarized the SHOC's operator with the engine throttle settings necessary for optimum skimming speed. By gauging the oil collected in the well, it was also possible to gain some experience so that the oil was not inadvertently flushed out of the well either by excess speed or a combination of speed and turning radius.

Once these preliminaries were over, the fireboat was pressed into service to assist the operation by concentrating the oil for subsequent pick up by the SHOC. An ideal configuration for concentrated oil is in long windrows down which the SHOC can move without too much turning. The Smith was, therefore, moored outboard of the dock and its bow and stern monitors used in an attempt to develop this type of configuration. Two firemen manipulated the fire streams, driving the patchy oil from around the boat out into the Kill. The streams were then used to drive the oil into a line parallel to the boat and about 150 ft away. There was an appreciable thickening of the oil along the line and the SHOC operator had an easily visible trail to follow as he moved the skimmer in to pick up the oil. The streams were used for 15 minutes and in that time concentrated the oil from an area approximately 150 ft square for pick up. The line of concentrated oil was not without a few twists and turns, but even on a first attempt, the firemen were able to set up a pattern easily traversed by the SHOC (Figure 3).

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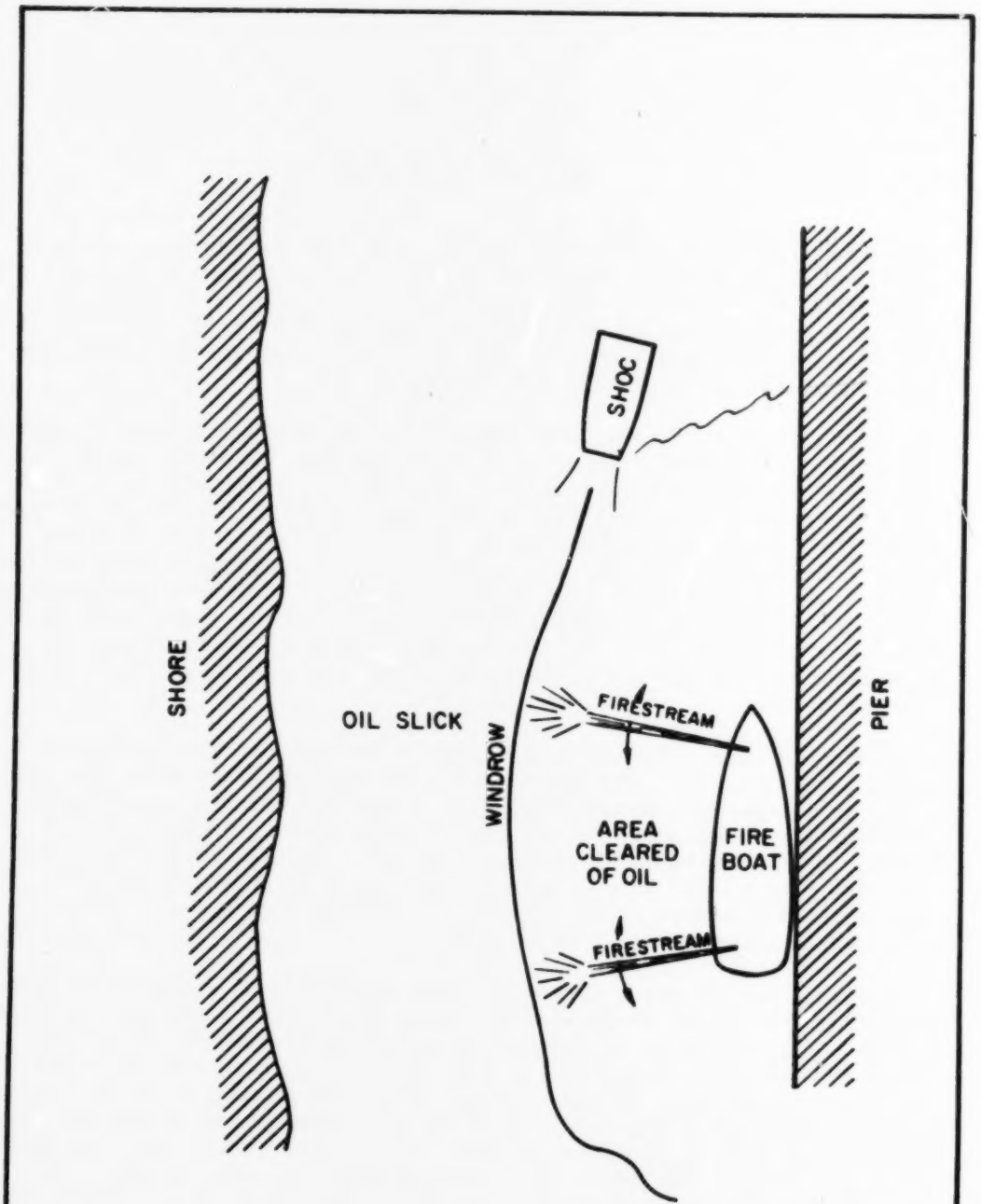

FIGURE 3

USE OF A FIRESTREAM TO CONCENTRATE OIL INTO WINDROW

The oil picked up on these runs was transferred to the onboard oil storage tank. The process was very slow because the skimming head in the collection chamber was fitted with a 1/2 inch mesh debris screen. The cold No. 6 oil was too viscous to pass through this screen efficiently.

Late in the afternoon a joint operation was planned with the Coast Guard in an effort to pick up additional amounts of oil on the open Kill. A long length of oil spill control boom was deployed in the shape of a U with the opening heading into the current. Two Coast Guard vessels took the ends in tow. The objective was to hold the boom so that oil would be concentrated in the bight for pick up by the SHOC. The experiment was unsuccessful for two reasons: 1) The location of the spill was just up-current from a bridge connecting New Jersey and Staten Island, and sufficient way had to be maintained on the boom to prevent its drifting down on the bridge abutments, 2) At the time of the test the current was in excess of 1.5 knots. When the light fence-type boom was held still relative to the shore, the current was strong enough to cause corkscrewing of the boom at the center of the U. The oil was all lost downstream. The operation of using fire streams without booms for oil spill control was, in this instance, more successful than an attempted use of available boom.

SECTION VII

EXTRAPOLATION OF EXPERIENCES

Based upon these first-hand spill experiences and previous experience developed in the use of large caliber fire streams, certain generalizations can be made regarding the potential use of fire streams in conjunction with virtually any type of self-propelled oil spill skimmer. Further, the principles developed apply equally well to the use of skimming barges without the self-propelled capability. The principal benefit of the use of fire streams appears to be the manipulation of an oil slick which is being moved by the wind or with a natural current. Movement of oil transverse to the direction of a natural current requires little energy compared to that required to tow a boom against this current for the purpose of collecting the oil. Fire streams can, therefore, be used successfully to compress or windrow a slick and facilitate cleanup. Three potential configurations of the use of fire streams in conjunction with wind and natural current, with and without boom, are presented in Figures 4, 5 and 6. One should note that there are two distinct benefits to these suggested configurations: Vessel traffic can pass through the cleanup area unrestricted, and interference from floating debris is minimized. When the SHOC skimmer is used, the natural current must exceed the minimum pick up speed of the boat. This requirement is not necessary with those types of skimmers which have pick up capability when the boat is stationary.

There is no doubt that the nation's fire departments can make a significant contribution to the control of oil spills. The major elements needed to provide this contribution are inherent in most fire departments, and only minor amounts of supplemental equipment and training are required to build up a major oil spill control capability.

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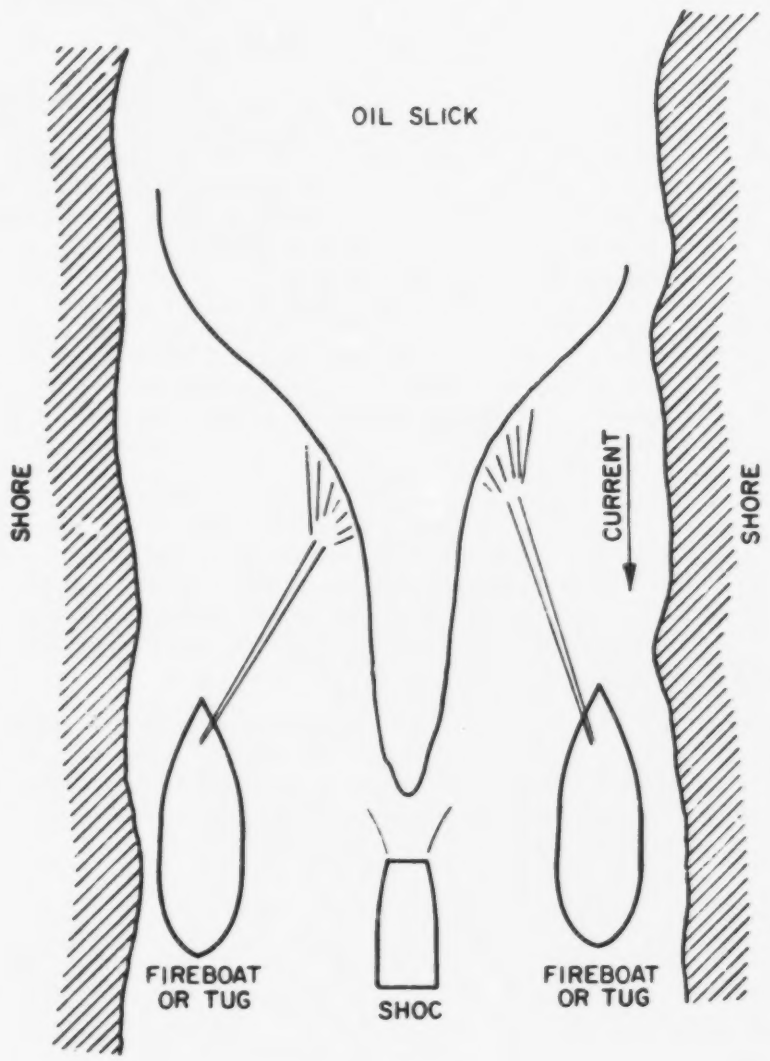

FIGURE 4

USE OF TWO FIRESTREAMS IN CONJUNCTION WITH A NATURAL CURRENT FOR SKIMMING OPERATIONS WITHOUT BOOMS

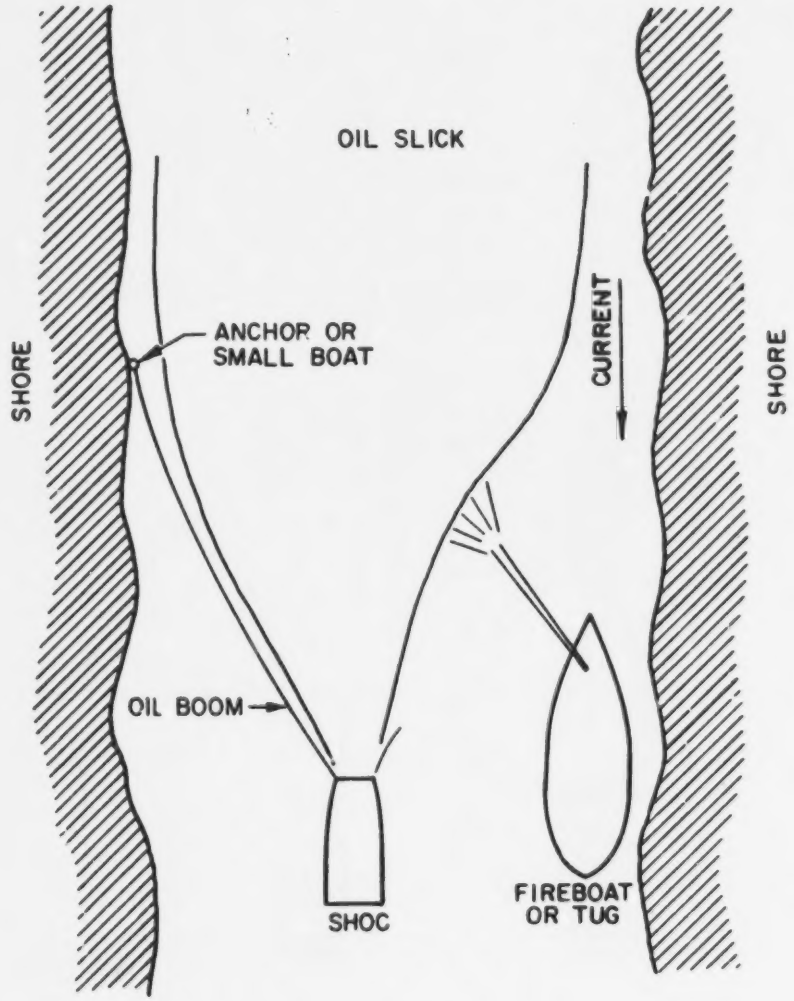

FIGURE 5
USE OF A FIRESTREAM IN CONJUNCTION WITH A NATURAL CURRENT FOR SKIMMING OPERATIONS WITH A SINGLE BOOM

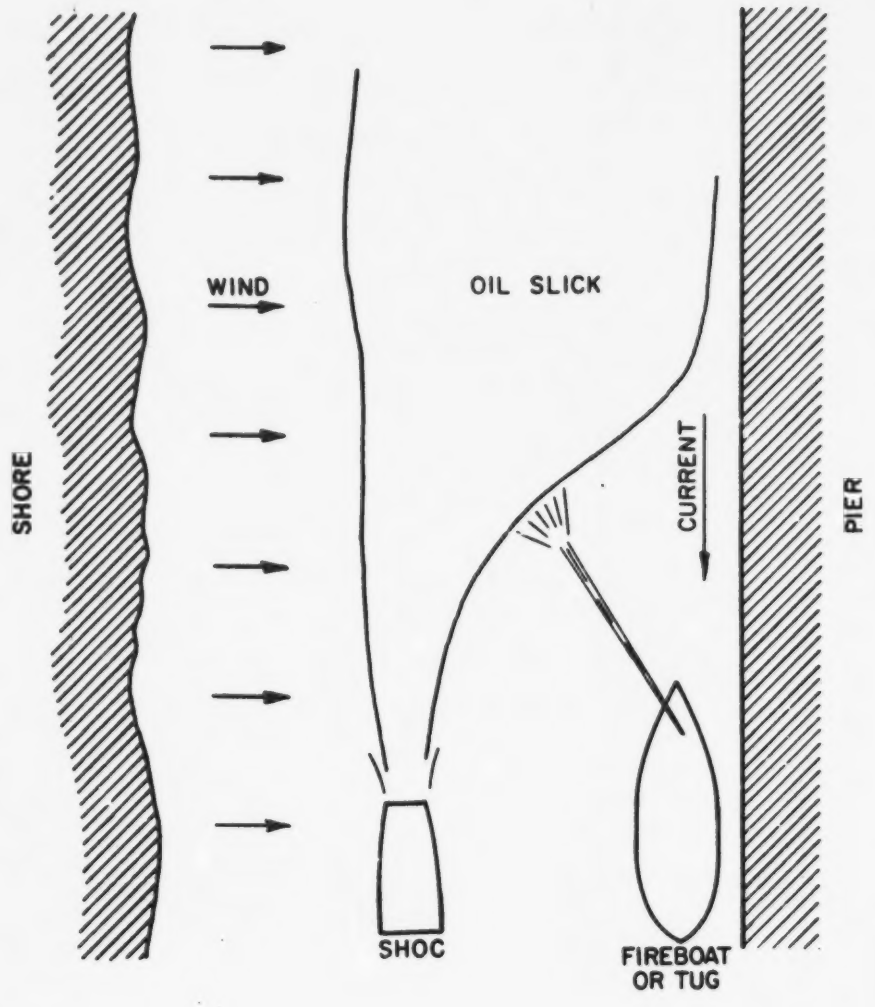

FIGURE 6

USE OF A FIRESTREAM IN CONJUNCTION WITH A NATURAL CURRENT AND WIND FOR SKIMMING OPERATIONS WITHOUT BOOMS

SECTION VIII

ACKNOWLEDGMENTS

The practical use of fireboats and other apparatus at actual spills and at numerous test exercises provided the basic information for this report. The Officers and Members of the Marine Division of the NYFD and the personnel of Alpine Geophysical Associates were the principal project participants.

The guidance of Mr. Frank Freestone, EPA Project Officer, and the cooperation of the City of New York and the U.S. Navy in providing the test basin at Wallabout Creek, Brooklyn, New York, is gratefully acknowledged.

SECTION IX

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1. Bianchi, Ralph and George Henry, "The Development and Demonstration of an Underwater Oil Harvesting Technique", Water Pollution Control Research Series Contract #14-12-899, Environmental Protection Agency, February, 1972.

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